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## Flathead and Lake County LiDAR Control December 15, 2009

River Design Group, Inc. has completed the required control survey necessary to establish horizontal and vertical coordinates for the Flathead County LiDAR Acquisition.

The following established positions were utilized in this survey.

### NGS CORS (continuously operating reference stations)

1. **MTFV** - located in Kalispell, MT.
2. **PLS6** - Located in Polson, MT

### NGS Vertical Monuments

1. **F442** - as described on NGS Datasheet
2. **K443** - as described on NGS Datasheet
3. **Z443** - as described on NGS Datasheet
4. **A444** - as described on NGS Datasheet
5. **A507** - as described on NGS Datasheet
6. **Whitefish** - as described on NGS Datasheet

### Newly established Control Monuments

1. **STUMPTOWN**
  - established by NW Chapter Marls for 2009 Height MOD
  - Position to be published by NGS in 2010
2. **STUMPTOWN secondary**
  - established as a redundant GPS Position
3. **F442 secondary**
  - established as a redundant GPS Position
4. **FERNDALE primary**
  - established as Primary GPS Position due to lack of existing monumentation
5. **FERNDALE secondary**
  - established as a redundant GPS Position
6. **A507 secondary**

### Aerial Triangulation Pre-Marks

- Painted Targets SV 1 to SV 12

## DATA COLLECTION METHODOLOGY

Utilizing Trimble R8 survey grade GPS receivers, multiple redundant long (> 4 hour) GPS static observations were measured on each newly established control point with concurrent and equal length static observations on the NGS vertical monuments (K442, K443, Z443, A444 & A507). Elevations were established for newly set monuments via differential leveling utilizing a Topcon DL103 Digital Level.

### **NOTES:**

1. STUMPTOWN and STUMPTOWN secondary elevations were established via Differential Leveling from WHITEFISH.
2. FERNDALE and FERNDALE secondary are Geoid03 quality elevations due to lack of 3d monumentation in the vicinity.

## STATIC OBSERVATION PROCESSING METHODOLOGY

The static occupations discussed above were processed and adjusted against the two NGS CORS positions utilizing Trimble Geomatics Office ver. 1.63. These solutions were used to provide survey grade horizontal solutions and geoid03 vertical solutions. The geoid03 solutions for K442, K443, Z443, A444 & A507 were then compared to the published vertical positions reported by NGS. *(This is necessary to analyze these vertical deltas to find the error in local geoid heights and to isolate possible disturbed or inaccurate vertical monuments.)*

## FINAL GEODETIC COORDINATES

**Horizontal Datum:** North American Datum of 1983 (CORS)  
**Horizontal Projection:** Montana State Plane  
**Horizontal Units:** (ussft) United States Survey Feet  
**Vertical Datum:** NAVD88 North American Vertical Datum of 1988 - Geoid03  
**Vertical Units:** (ussft) United States Survey Feet

sta	northing (ussft)	easting (ussft)	elevation (ussft)
WF Airport	1552499.1290	801687.2900	3050.34
WF Airport (secondary)	1552480.1200	801677.0340	3050.89
NGS F 442	1445038.2650	807979.1550	2912.34
NGS F442 (secondary)	1445053.8060	807984.1430	2912.70
Ferndale (primary)	1417603.0100	867473.0000	3066.99
ferndale (secondary)	1417607.4730	867414.8780	3066.93
K 443	1343787.2200	782200.7330	2944.47
NGS Z 443	1304227.4640	809124.0600	3094.62
NGS A 444	1300323.8200	811816.0030	2974.95
SV-08	1354932.8400	858174.7720	2963.60
SV-12	1284967.4150	843888.0940	2935.59
SV-11	1310103.5790	805974.2170	3428.13
SV-10	1340835.2250	777899.7060	2926.52
SV-02	1553701.7850	807116.3790	3100.05
SV-03	1531877.2040	838041.5110	3091.56
SV-04	1513583.3060	769979.7910	3137.69
SV-01	1578930.4900	772913.1370	3006.58
SV-09	1373403.8660	902655.4200	3081.63
SV-06	1454510.8710	850466.1170	3035.35
SV-07	1407708.7490	807188.2310	3082.46
SV-05	1478941.7910	816425.4380	2936.25
NGS A507 (SECONDARY)	1513663.5540	813440.1300	2963.23
NGS A 507	1514631.6270	813273.0640	2967.76

sta	latitude	longitude	height (ussft)
WF Airport	48°24'36.47915"N	114°18'30.39731"W	2997.69
WF Airport (secondary)	48°24'36.28566"N	114°18'30.53178"W	2998.27
NGS F 442	48°07'01.42707"N	114°15'20.60613"W	2860.07
NGS F442 (secondary)	48°07'01.58321"N	114°15'20.54662"W	2860.43
Ferndale (primary)	48°03'05.74842"N	114°00'21.65367"W	3015.84
ferndale (secondary)	48°03'05.75942"N	114°00'22.51189"W	3015.79
K 443	47°50'08.06192"N	114°20'07.84518"W	2893.19
NGS Z 443	47°43'54.37511"N	114°12'58.82530"W	3043.57
NGS A 444	47°43'17.49697"N	114°12'16.06767"W	2923.95
SV-08	47°52'42.73083"N	114°01'45.00981"W	2913.14
SV-12	47°41'04.86871"N	114°04'14.44625"W	2885.39
SV-11	47°44'50.41685"N	114°13'50.03322"W	3377.11
SV-10	47°49'36.34566"N	114°21'08.11760"W	2875.37
SV-02	48°24'51.60839"N	114°17'11.14315"W	3047.49
SV-03	48°21'34.95439"N	114°09'14.19312"W	3039.20
SV-04	48°17'53.63403"N	114°25'43.28965"W	3085.20
SV-01	48°28'39.21779"N	114°26'00.83321"W	2954.67
SV-09	47°56'09.69683"N	113°51'08.24309"W	3032.38
SV-06	48°08'59.77185"N	114°05'03.44287"W	2983.26
SV-07	48°00'53.08824"N	114°14'58.89186"W	3030.88
SV-05	48°12'40.56239"N	114°13'46.47019"W	2883.23
NGS A507 (SECONDARY)	48°18'20.91574"N	114°15'01.56654"W	2910.03
NGS A 507	48°18'30.35446"N	114°15'04.90241"W	2914.56

CONTROL PT	monuments	gps quality	vertical method
WF Airport	steel rod in casement	NAVD88 control	differential level
WF Airport (secondary)	2" alum cap (rdg)	NAVD88 control	differential level
NGS F 442	NGS (per datasheet)	NAVD88 control	NGS control
NGS F442 (secondary)	2" alum cap (rdg)	NAVD88 control	differential level
Ferndale (primary)	2" alum cap (rdg)	NAVD88 geoid 03	geoid03 observation
ferndale (secondary)	2" alum cap (rdg)	NAVD88 geoid 03	geoid03 observation
K 443	NGS (per datasheet)	NAVD88 control	NGS control
NGS Z 443	NGS (per datasheet)	NAVD88 control	NGS control
NGS A 444	NGS (per datasheet)	NAVD88 control	NGS control
SV-08	pk nail-brass washer	NAVD88 geoid 03	geoid03 observation
SV-12	pk nail-brass washer	NAVD88 geoid 03	geoid03 observation
SV-11	pk nail-brass washer	NAVD88 geoid 03	geoid03 observation
SV-10	pk nail-brass washer	NAVD88 geoid 03	geoid03 observation
SV-02	pk nail-brass washer	NAVD88 geoid 03	geoid03 observation
SV-03	pk nail-brass washer	NAVD88 geoid 03	geoid03 observation
SV-04	pk nail-brass washer	NAVD88 geoid 03	geoid03 observation
SV-01	pk nail-brass washer	NAVD88 geoid 03	geoid03 observation
SV-09	pk nail-brass washer	NAVD88 geoid 03	geoid03 observation
SV-06	pk nail-brass washer	NAVD88 geoid 03	geoid03 observation
SV-07	pk nail-brass washer	NAVD88 geoid 03	geoid03 observation
SV-05	pk nail-brass washer	NAVD88 geoid 03	geoid03 observation
NGS A507 (SECONDARY)	2" alum cap (rdg)	NAVD88 control	differential level
NGS A 507	NGS (per datasheet)	NAVD88 control	geoid03 observation

### LiDAR Absolute Accuracy

River Design Group collected 1000 sample points to test the accuracy of the final LiDAR surface. Each of these points were classified by average ground cover and land type and sampled against the Final Surface.

The Results of this analysis are as shown below:

	asphalt	Cat tails	concrete	cultivated fields	drain rock	grass	grass lawn	gravel	natural fields	packed dirt	shrubs
$\Delta$ Average Elevation	-0.04	1.00	-0.12	0.12	0.10	0.21	0.07	0.07	0.26	0.05	0.26
$\Delta$ Minimum Elevation	-0.33	0.27	-0.57	-0.07	-0.19	-0.19	-0.23	-0.29	-0.36	-0.35	-0.66
$\Delta$ Maximum Elevation	0.27	1.66	0.34	0.41	0.28	0.62	0.37	0.44	0.94	0.46	0.94
Average Magnitude	0.12	1.00	0.18	0.13	0.16	0.24	0.13	0.14	0.29	0.16	0.54
Root Mean Square	0.14	1.04	0.23	0.16	0.18	0.28	0.16	0.18	0.36	0.20	0.57
Standard Deviation	0.14	0.30	0.20	0.11	0.15	0.20	0.15	0.16	0.25	0.20	0.52



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Andrew P. Belski, PLS  
Montana Professional Land Surveyor 14731PLS

Date

**Montana Office**  
5098 Highway 93 South  
Whitefish, Montana 59937  
(406) 862-4927 • Fax (406) 862-4963

**Oregon Office**  
311 SW Jefferson Avenue  
Corvallis, Oregon 97333  
(541) 738-2920 • Fax (541) 758-8524